Neonatal Identification Screening for Hearing Impairment: A Comparison of the Utah Maternal Questionnaire and Birth Certificate

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NEONATAL IDENTIFICATION SCREENING FOR HEARING IMPAIRMENT:
A COMPARISON OF THE UTAH MATERNAL QUESTIONNAIRE
AND BIRTH CERTIFICATE

by

Carl Hugh Clark

A thesis submitted in partial fulfillment
of the requirements for the degree
of
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in
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Plan A

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Logan, Utah
1980
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Carl H. Clark
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ABSTRACT

Neonatal Identification Screening for Hearing Impairment: a Comparison of the Utah Maternal Questionnaire and Birth Certificate

by

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Utah State University, 1980

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The purpose of this study was to compare the Utah maternal questionnaire and birth certificate as they relate to the identification of hearing impairment in infants. Comparative data relating to rate of return, number of high risk infants, number of at risk infants, number of hearing impaired infants, false positive rates, and item analysis were obtained for both screening instruments. Tabulation of the results showed the birth certificate to be a better neonatal screening device of hearing impairment than the maternal questionnaire. The birth certificate maintained a low false positive rate and a high rate of identification of hearing impairment in infants.
CHAPTER I
INTRODUCTION

Early identification appears to be an extremely important factor in optimizing the effect of treatment of hearing impaired infants. Some investigators have suggested that identification later than one year results in stimulus deprivation. This deprivation may not be overcome by intensive teaching or by the use of hearing aids (Pollack, 1975; Norton, 1975; Northcott, 1975). Young stated, "The poor language outcome of so many educationally deaf children resides in late identification rather than lack of, or poor teaching methods." (Young, 1976)

Utah State Department of Health, Speech Pathology-Audiology Division has developed and implemented the only statewide hearing screening method in the United States. This method could serve as a model for other states.

This research was conducted to obtain information concerning the effectiveness of the Utah maternal questionnaire and birth certificate as methods of neonatal identification screening for hearing impairment. The following topics are briefly described in order to establish background information: rationale for early identification, behavioral screening, the high risk register, development and outcome of the maternal questionnaire, background of the birth certificate, and the purpose and objectives of the study. Following the brief introduction, there will be a detailed discussion concerning: (a) rationale for screening newborn infants, (b) behavioral audiometric screening for hearing impairments, (c) brainstem evoked audiometry screening for hearing impairments, and (d) high risk screening for hearing impairments.
The importance of early identification was noted as early as 1928 by Aldrick. He developed a behavioral screening process in which (Mencher, 1976) he could elicit a behavioral response from a child by ringing a bell. This was the beginning of behavioral screening. Mencher (1975) explained that the term behavioral screening was a result of the procedures employed by Aldrick. This method consisted of behavioral observations made of a newborn's responses to noise makers. If a child during the presentation of the sound failed to respond by any overt movement, he was termed at risk for a hearing impairment. Even with the advent of new procedures and inventions, behavioral screening could offer little more than a dim hope of effectively identifying the populace in question. Gerber (1977) stated that deafness doesn't just happen, but is caused. With the knowledge of the cause of deafness one should be able to anticipate severe auditory problems at birth and thereby facilitate the prevention or amelioration of the handicap. It was with this philosophy in mind that several attempts have been made to produce a method by which children with common high risk factors could be identified. In 1973, a conference on Newborn Hearing Screening was held with the goal of developing a more reliable method of identifying infants with hearing impairments. From the proceedings of the conference, it was recommended that an emphasis be placed upon the identification of a high risk population and that a follow-up registry on those at risk be employed. The following is a statement by the committee of the Nova Scotia Conference on the High Risk Register (Mencher, 1976; p. 497):

The Committee recommends that, since no satisfactory technique is yet established that will permit hearing screening of all
newborns, infants AT RISK for hearing impairment should be identified by means of history and physical examination. These children should be tested and followed up as hereafter described:
The criterion for identifying a newborn as AT RISK for hearing impairment is the presence of one or more of the following:
A. History of hereditary childhood hearing impairment.
B. Rubella or other nonbacterial intrauterine infection (e.g., cytomegalovirus infections, Herpes infection).
C. Defects of ear, nose, or throat. Malformed, low-set or absent pinnae; cleft lip or palate (including submucous cleft); any residual abnormality of the otorhinolaryngeal system.
D. Birthweight less than 1500 grams.
E. Bilirubin level greater than 20 mg/100ml serum.

Since that conference studies have been performed to assess the validity of the high risk criteria (Downs & Stewart, 1977; and Mencher, 1978). According to these studies the use of a high risk register is highly recommended.

Following the guidelines recommended in the 1973 Joint Committee's statement, the Utah State Division of Health revised a previous high risk form into a maternal questionnaire. The maternal questionnaire employed all five high risk criterion plus a question regarding neonatal illness and parental concern. In a reporting period for 1976, they experienced a return rate of 62% of the questionnaires. Seventeen percent were at risk. In follow-up audiological testing, ten percent of the high risk infants were confirmed as having hearing losses (Clark & Watkins, 1978). Several problems cited by Mahoney (1977) were:
1. Difficulty in obtaining state wide hospital participation.
2. Difficulty in screening intensive care babies.
3. Patient follow-up.
4. Low return rate on high risk questionnaires.
5. High false-positive rate in the maternal questionnaire.

In an effort to eliminate the above problems, the Utah State Department of Health requested that the Utah Birth Certificate be revised to include a statement concerning history of hereditary childhood hearing impairment. With the adoption of the hereditary question, problems experienced by the maternal questionnaire would hopefully be eliminated.

Research Problem

Treatment of hearing impairment in children is often complicated and/or delayed by the late identification of the handicap. The problem, therefore, relates to the identification of hearing impaired infants as early an age as possible in order to ensure optimal habilitation.

Objective

The objective of this study is to compare specific characteristics of the Utah maternal questionnaire and the Utah birth certificate as they relate to the identification of hearing impairment in infants. The researcher sought to obtain comparative information on the following: (a) rate of return, (b) differences regarding the number of infants identified as high risk and at risk, (c) items of risk responsible for being classified as at risk, (d) actual number of infants with hearing loss, (e) items of risk identified for those with a confirmed hearing loss, and (f) false positive rates.
Delimitations

This study examined the differences between the yields of the maternal questionnaire and the high risk birth certificate in Utah. As stated by the reporting period of 1976, the maternal questionnaire experienced only a 62% return rate whereas the high risk birth certificate should experience a return rate of nearly 100%. The study is not a random sample but includes all available records. No attempt is made to control such variables as: intelligence, socio-economic, professional, or emotional factors which may have been related to persons responding to the high risk questions on either form of screening.

Operational Definitions

1. High risk. Those infants identified by the initial screening device by one or more risk item for hearing impairment.

2. At risk. Those infants who remain at risk following the follow-up questionnaire.

3. Hearing risk. The at risk infants who's parents indicated concern about their child's hearing on the follow-up letter.

4. Phenylketonuria (PKU). A rare genetic anomaly in man portrayed by the inability to oxidize phenypyruvic acid leading to severe mental deficiency.

5. Hyperbilirubinemia. Excessive amounts of bilirubin which is the principle pigment of live bile. Commonly referred to as jaundice.

6. Apgar Score. A score based on the attendings physicians evaluation of the infants heart rate, respiration rate, and body color. A score below five is indicative of problems.

7. Source Document. A computer printout which contains personal
information, data regarding risk items, description of the handicap, and services being rendered.
CHAPTER II
LITERATURE REVIEW

The review of literature provides an understanding of the rationale for neonatal screening and the different methodologies used in identifying hearing impairments. This review was conducted in four specific areas: (1) rationale for neonatal screening for hearing impairments, (2) behavioral audiometric screening for hearing impairments, (3) electrophysiological screening for hearing impairments, and (4) high risk screening for hearing impairments.

Rationale for Neonatal Screening for Hearing Impairments

Froding (1960) reported that a century ago it was suggested that newborn babies were, if not indeed deaf, insensitive to auditory stimulation. This theory was seriously challenged by the close of the nineteenth century. More recent studies (Ewing & Ewing, 1965; Downs & Sterritt, 1967; and Friedlander, 1975) have demonstrated quite conclusively that the infant's capacity to respond to sound is quite remarkably developed. Eisenberg (1970) showed that a twenty-four hour old newborn has the capability of responding selectively to relatively fine auditory signal differences. With this being the situation, newborn hearing screening programs were developed (Watrous, McConnell, Sitton & Fleet, 1975).

A major motivation for developing procedures for detecting hearing impairment in infants is the realization that language and auditory skills are most effectively developed during the first few years of life (Lloyd, 1976). Research in the literature suggested a critical period for language acquisition in the life of every child. It is during
the first few years that a child's language emerges rapidly and effortlessly. Researchers have stated that the first two years are biologically programmed for language learning and are thereby important in an infant's early maturational period of life (Tervoort, 1964; Edwards, 1978; Lenneberg, 1967; and McNeil, 1977). Menyuk (1977) stated that as early as the babbling stage, the normal infant is making both perceptual and productive categorizations of the speech signal, which may be crucially important in later language development. "Therefore", she stated, "the term 'early' in early detection turns out to be very early indeed."

Havine (1967) and Meadows (1967) supported Menyuk's statement that if language is not developed during the early years of a child's life, little more than remedial work can be done, since language will never develop spontaneously. Language acquisition is a one-time occurrence and that time is in the early years of life (McCroskey, 1969; Downs, 1967).

Cole (1979) stated, "No chronic disability is more prevalent among young children today than impaired hearing." Infancy and early childhood are the periods of most rapid brain growth and a time when speech habits are most easily acquired. Moreover, infancy is not only the normal period for speech development, but it encompasses the crucial years for it (Cole, 1979). Young stated that "The poor language outcome of so many educationally deaf children resides in the late identification, rather than lack of, or poor teaching methods." (Young, 1976)

Even though the incidence of hearing impairment is not high, there is a significant population of deaf children born every year. A study conducted by the Department of Health, Education, and Welfare established
an incidence of at least one child in every two thousand births as being deaf or severely hard of hearing (Clark & Watkins, 1978).

Utah alone with a criterion of one out of every two thousand incidences of congenital hearing loss would yield a 4.5 child identification every three months (Clark & Watkins, 1978). With the same criterion holding true, out of the 3.5 million babies born in this country annually about two thousand to three thousand of them will be deaf at birth. If these infants are identified during the neonatal period, difficulties later confronting them may be alleviated (Korones, 1978).

If hearing defects can be identified before age two, the possibility of an effective program is enhanced. This will enable the deaf child to receive language stimulation during the period of maturational readiness. Downs (1971) stated that a one-month old deaf infant can receive language through amplification if he has sufficient residual hearing. Gerber (1977) claimed that, "the detection and habilitation of one deaf infant can be shown to be less than the cost of later rehabilitation," and Mencher (1974) further claimed that each year of early detection saves $10,000.

The following are statements from the literature which are supportive of neonatal screening:

1. The neonatal period is the only time when the infant is fully available: More than 95% are born in the hospital. Professionals and volunteers are readily available (Hardy, 1978).

2. Although the yield of children with actual incidence of hearing impairment is low in comparison to the overall population, those who are found may have been missed and thus suffer the consequences of late identification (Hardy, 1978).
3. Consequence of untreated and unidentified hearing losses are: complete lack of speech or language development at ages when these functions should be well implanted, deterioration of parent-child relationships into forms of rejection or bewildered overprotection, and personal deviations ranging from withdrawal to acting out or hyperactivity (Northern & Downs, 1978).

4. A true hearing loss can be ameliorated, if the disorder is given proper treatment (Northern et al, 1978).

5. Benefits far outweigh the low identification level in that the child who is identified will receive optimum habilitation for his handicap (Downs & Sterritt, 1967).

6. The accepted phenylketonuria or PKU screening program identifies one child in every 14,000 births (Northern & Downs, 1978). As stated by Clark & Watkins (1978), a hearing program would identify one child in every 2000 births.

Behavioral Audiometric Screening for Hearing Impairment

Behavioral screening has been a means of identifying infants with hearing impairments. This section will discuss: (a) definition, (b) historical background, (c) Marion Down's baby beeping screening program, (d) non-nutrient sucking screening program, (e) crib-o-gram screening program and (f) the advantages and disadvantages of each program.

Behavioral audiometry is a general term used to describe audiometric procedures that are designed to judge operant responses to sound. In the case of newborn behavioral screening, it is audiometric techniques used to elicit reflex responses to sound (Lloyd & Dahle, 1976). Reflex responses to gross auditory stimuli have been shown to be easily
observable in newborn infants (Wedenberg, 1956; Froding, 1960; Hardy, Doughert & Hardy, 1959; and Susuki & Sato, 1961).

Aldrick (1928) introduced behavioral screening for newborns. He noted that he could pair a response of a ringing bell and scratching the bottom of a foot of two to three month old infants. The elicited response was a retraction of the foot. Specification of the customary audiometric parameter—frequency, intensity, and duration—underwent the scrutiny of investigation since Aldrick's original study (Haller, 1932; Stubbs, 1934; Eisenberg et al., 1966; Downs & Sterritt, 1967; Ling et al., 1970; Rudmose, 1967; and Gerber, 1977). Given the findings of the above studies the Nova Scotia Conference of Early Identification of Hearing Loss (Mencher, 1976) recommended a specific stimulus spectrum. For the test stimulus it recommended a random noise having a low-frequency attenuation of 30 dB/octave below 750 Hz, a maximum of 90 dB sound pressure level at the pinna, a rise-decay time of five milliseconds or more, duration of 0.5-2.0 seconds, and an interval minimum of 15 seconds. The Committee further recommended that an infant's response is any generalized body movement that involves more than one limb and is accompanied by some form of eye movement. The observation should be recorded by two observers independently or by the use of one observer who does not know when the stimulus is present. The behaviors must occur twice in eight consecutive trials for the infant to be cleared as normal (Mencher, 1976).

'Baby beeping' screening. Downs (1967) prepared a manual describing a newborn hearing screening program. The program incorporated the use of a Vicon Apriton or 'baby beeper' that produced a narrow band of
noise used to elicit a behavioral response form an infant. In a study by Downs & Hemmingway (1969), 17,000 infants were screened by trained observers. Over 500 failed the initial evaluation and 15 of those were found to have a hearing loss. Shapiro (1974) reported on newborn screening in a country hospital using the 'baby beeping' method. He reported that their experience was not as effective as that of Downs and Hemmingway in 1969. They failed to identify any babies who had a confirmed hearing loss.

Supportive factors taken from the literature for 'baby beeping' for screening of newborn infants for hearing loss are:

1. 'Baby beeping' provides a check-out at birth and a reference point against the later detection of a hearing impairment (Hardy, 1978).

2. Routine screening may provide information regarding presence of other more general or more pervasive disorders in an infant who fails to respond normally (Goldstein & Tait, 1971).

There are several statements in the literature which demonstrate genuine reservations concerning the use of 'baby beeping':

1. After investigation by the Committee of the Nova Scotia Conference, behavioral screening was recommended to be used only in conjunction with a high risk register (Mencher, 1976).

2. Many of the children with a hearing impairment were not discovered. A large population of false positives were also a source of problems (Goldstein & Tait 1971).

3. An overall lack of success was experienced in identifying children with congenital rubella, due to the progressive nature of the virus and the existence of some residual hearing (Hardy, Hardy & Hardy, 1970).
4. Problems were experienced with reliability of observers, stimulus-response variables, non-responding infants, and habituation or testing environment (Ling, 1972; Moncur, 1968; Eisenberg et al., 1966; Goldstein & Tait, 1971).

5. Question of cost efficiency was sited (Northern et al., 1978).

6. Simmons (1977) stated that the cost of screening by behavioral observations were simply too high and the pay off too irregularly dependant upon the observer's skills.

**Non-nutrient sucking behaviors.** An automated behavioral hearing screening method was developed using the non-nutrient sucking response of newborn infants (Kron, 1972; Trehub & Rabinovitch, 1972; and Lipsitt, 1974). Peck and Kasden reported to have observed alterations in sucking behavior during presentation of pure tone stimuli (Regan & Charbonneau, 1977). These investigators primarily used an electronically monitored pressure transducer with a standard infant feeding nipple attached to record the infants sucking response. The use of an adapted Bekesy automatic audiometer was implemented to monitor the sucking responses to sound presentations (Eisele, Berry & Shriner, 1975). In the study conducted by Eisele, Berry, and Shriner (1975), a high consistency of non-nutrient sucking responses to sounds was reported for 100 out of 105 neonates tested. Test-retest reliability was high for ten randomly selected infants. They concluded that the sucking response technique showed a great promise in the identification of hearing impaired neonates. In a later study, Regan and Charbonneau (1977) reported that of 31 infants with normal hearing, eight could not be evaluated due to lack of cooperation. Of the 23 remaining, 21 responded consistently
at 50dB intensity for all frequencies tested. They concluded that the results suggested an inexpensive, objective, and an easy to administer method of assessing hearing at a moderate intensity level.

Cited are several comments in favor of neonatal screening by means of non-nutrient sucking patterns.

1. Non-nutrient sucking screening could be an inexpensive, objective, and an easy to administer method for the identification of hearing impairment (Regan & Charbonneau, 1977).

2. There isn't any problem with habituation or problems with observation validity (Semp & Lipsitt, 1968).

Several viewpoints in opposition to non-nutrient sucking responses were found in the literature:

1. Further investigation is needed because of the lack of data (Regan & Charbonneau, 1977, and Eisele et al., 1975).

2. Difficulty in obtaining respondent behaviors in 25% of the normal infants was of noted concern (Regan & Charbonneau, 1977.)

Crib-o-gram screening. The Crib-o-gram is a completely automated system for detecting hearing loss in newborns (Simmons, 1977). This technique involves a motion sensitive transducer placed beneath or in each infant's crib. The transducer is capable of detecting virtually any motor activity stronger than an eye blink (Northern & Downs, 1978). A strip chart can be attached which automatically records the infants motor activities prior to, during, and after presentations of auditory stimuli. Auditory test stimuli are presented 20 times each twenty-four hours and are controlled by a self-cycling system. Simmons & Russ (1974) explained the test sequence as seven second period for recording a
baseline motor activity, a presentation of a one second test sound, and a six second period for recording crib motion activity changes. The cycle runs for a duration of about 14 seconds. Responses are scored by experienced readers. Simmons (1977) stated that the crib-o-gram can be designed to monitor 30 or more cribs. The following are supportive statements from the literature for the crib-o-gram.

1. It offers promise in that there are no interferences with nursery routine, no subjective response criteria, and it is self contained (Simmons, 1977).

2. It is fully automated, and therefore, eliminates problems with observer reliability and stimulus variability (Simmons & Russ, 1974).

The following are problems discussed in the literature concerning the crib-o-gram.

1. A problem exists with regards to the optimal time when nursery noise is lowest and the majority of newborns are in their cribs and are in a state of behavioral readiness for stimulization (Northern & Downs, 1978).

2. In the studies of Simmons, a false positive rate of 11.3% existed (Simmons & Russ, 1974).

3. Rooming mothers and early discharges are not readily available for screening (Northern & Downs, 1978).

**Brainstem Evoked Response Audiometry (BSER)**

An example of electrophysiological screening used with neonatal and hard to test populations is BSER. Brainstem evoked response audiometry appears to be a promising measurement of an infant's hearing (Gerber, 1977).
BSER involves the measurement of electrical activity generated in response to an auditory signal by the brainstem (Clark & Shapiro, 1975). The human brain continually generates electrical potentials like those in nerves and muscles; many of which are strong enough to be monitored by use of an electroencephalogram (EEG). With the advent of the averaging response computer, elimination of the random background activity and the summation of the electrically evoked responses were made possible (Stein, 1976).

Through the use of a series of clicking sounds the auditory nervous system is stimulated. Under earphones, these clicking sounds are presented to the person. The electrical activity evoked by the sounds in the brain are picked up by electrodes placed behind each ear and on the top of the head. These electrical signals are amplified and printed by a computer as wave forms (Clark & Shapiro, 1975). Within 12.5 milliseconds of a click, the computer will print out a graph of seven distinct peaks each representing a point along the auditory pathway (Jewett & Williston, 1971). There is a finite time required for the generation of electrical potentials from each of the various auditory structures and areas of the brain following a sound presentation. It is the interval between stimulation and the response or what is termed the latency that is the most important factor in the study of the evoked responses (Stein, 1976).

Jewett and Williston (1971) recorded the early component of evoked responses and labeled the seven peaks. They attributed different neurological centers as bases for five of the newly labeled Jewett bumps. They were: (J1) auditory nerve, (JII & JIII) cochlear nuclei, trapezoid
body and superior olivary nuclei, and \((J_{VI} & J_{V})\) the lateral lemniscus, and inferior colliculus (Northern & Downs, 1978).

In the case of a normal infant, the computer prints out seven distinct peaks within a 12.5 millisecond time frame. If a baby has a hearing impairment, the peaks take longer to appear or have a longer latency. Different types of hearing defects will produce wave patterns that deviate from the normal in characteristic ways (Stein, 1976; Schulman-Galambos & Galambos, 1975; Gerber, 1977; and Hood, 1975). The following are factors in favor of BSER in identifying hearing impairment in neonates.

1. There are not any subjective response criteria and is fully automated (Gerber, 1977).

2. Responses can be reliably obtained at moderate stimulus intensity levels (Gerber, 1977).

Several statements found in the literature express hesitations in using BSER as a screening device.

1. Problems existing with equipment and the technical aspects of running the tests are often present (Northern & Downs, 1978).

2. The cost of equipment and trained personnel is expensive in comparison to other screening methods (Northern & Downs, 1978).

3. The test, at present, takes too long to be used as a routine screening measure and requires specialized training in the operation and the interpretation (Northern & Downs, 1978).

4. To insure cooperation, infants must be medicated to produce accurate results (Gerber, 1977).
High Risk Screening for Hearing Impairment

Due to the objections and shortcomings experienced by the previously cited methodologies and an upsurge in interest in neonatal screening, a conference was held in 1969. The conference was formed of representatives from the Academy of Pediatrics, the American Speech and Hearing Association, and the Academy of Ophthalmology and Otolaryngology. This Joint Committee discussed the use of behavioral test of neonatal screenings as proposed and explained by Downs and Sterritt (1964) and Mencher (1974). Critiques were examined. A statement from the Committee recommended that behavioral screening not be used as a mass screening devise (Northern & Downs, 1978).

As an alternative to behavioral screening, the Committee examined the studies of Hardy (1964) and Feinmesser and Tell (1976). Hardy (1964) proposed a high risk register consisting of five major headings and 23 subtopics. The rationale behind this register was criticized (Bradford, 1975). Feinmesser and Tell (1976) studied 17,731 newborns screened at birth by use of behavioral screening and subjection to a high risk register. After follow-up evaluations, 23 deaf children were identified, 17 of them had been screened using a high risk register, and only six had been identified by behavioral screening. They concluded that a high risk register could identify a satisfactory number of deaf infants using only a small number of categories (Northern & Downs, 1978). The Committee proposed a modification of that statement to include the implementation of a five point high risk register. The five etiological risk items were: (a) family history of hearing loss, (b) rubella, (c) ear, nose, or throat defects, (d) low birthweight, and (e) hyperbilirubinemia.
International support for a high risk register came as a result of the Nova Scotia Conference (Mencher, 1976). Upon examination of screening programs from various parts of the world, the Conference members recommended that the Joint Committee's five point register be adopted universally (Northern & Downs, 1978).

Feinmesser & Tell (1976) and Downs and Stewart (1977) have reported varying degrees of success using the high risk criteria. Feinmesser & Tell (1976) reported the identification of 17 out of 23 confirmed hearing losses using a high risk register. Downs et al. (1977) reported a yield of 16 out of 17 confirmed hearing losses from a population of 10,726 infants screened using the high risk register. Downs further reported that identification sensitivity increased by as much as 20 times by use of a high risk register in comparison to previously used behavioral methods Northern & Downs, (1978). Altman & Shenhau (1971) reported that over 75% of all children who would eventually suffer severe to profound hearing impairments can be identified using a high risk register.

Utah's High Risk Programs

Gerber (1977) reported that Utah began a Maternal and Child Health demonstration project in 1967. This program consisted of behavioral 'baby beeping' assessments and a high risk form. It was initiated in the Logan LDS Hospital. Watkins (1978) reported that the high risk form used proved to be too long and cumbersome for the attending physicians. In accordance with the recommendations of the Joint Committee of 1971, revisions were made in Utah's high risk form. Until 1973 and in accordance with the 1973 Joint Committee's statement, a
maternal questionnaire was introduced (Gerber, 1977). The maternal questionnaire employed a seven item risk register. The items included were: (a) hereditary hearing loss, (b) any exposure to rubella, (c) birthweight less than 1500 grams, (d) RH or blood incompatibility, (e) defects of head, ears, nose, or throat, (f) neonatal illnesses, and (g) parental concern.

Problems experienced with the physician filling out the lengthy forms were eliminated by having the mother respond to the questionnaire while she was in the hospital. A questionnaire was enclosed in a packet of materials given to the parents prior to the preparing of the birth certificate information. The hospitals collected the questionnaires and returned them to the State Division of Health. Personnel in the Speech Pathology/Audiology Section made decisions as to infants at risk or not at risk (Gerber, 1977).

Mahoney (1977) outlined the eight steps in the maternal questionnaire program as:

1. Maternal questionnaires are mailed to every hospital in Utah from the Speech Pathology/Audiology Section of the State Division of Health.

2. The questionnaires are distributed to mothers for completion along with the mandatory birth certificate forms.

3. Questionnaires are accumulated by the hospitals and returned to the Speech Pathology/Audiology Section on a regular interval.

4. Questionnaires are sorted by personnel as high risk or not high risk. "A positive response to one or more items constitutes a high risk determination, as does a failure to complete any item."
5. Following a six to eight month waiting period, deaths are purged from the high risk infants. A follow-up questionnaire is sent to the parents. It consists of the seven questions on the maternal questionnaire plus two additional questions regarding the child's auditory behaviors.

6. If auditory behavior is questionable or parental concern exists, either an audiological evaluation appointment is made or literature concerning hearing is mailed to the parents, in which case a follow-up phone call is made to assess parental observations.

7. Infants found to be hearing impaired are contacted in regards to hearing aid evaluation, medical consultation, and family physician referrals.

8. Habilitation referrals are made to the Parent Infant Program at the Utah School for the Deaf.

Mahoney (1977) reported a 62% return rate for maternal questionnaires from Utah hospitals. Of the nearly 35,000 questionnaires processed, about 16% were found to be at risk for a hearing impairment. Following the initial contact three percent remained at risk. Of the three percent at risk, about 13% were found to be hearing impaired through audiological evaluations.

Problems involving the maternal questionnaire were reported by Mahoney, Cozakos, Brockert, and Eichwald (1978) as: maintaining hospital interest and cooperation over an extended period (problem with low return rate) and problems relating to high false positive rate.

Because of these problems, a pilot program utilizing the Utah birth certificate as a means of identifying infants at risk for hearing
impairments was instituted (Mahoney et al., 1978). Upon investigation of the birth certificate, Mahoney et al., (1978) reported that information concerning four of the five recommended high risk criteria were already present on the birth certificate. The fifth criterion, which relates to the history of hereditary childhood hearing impairment, was added in 1978 following approval of the Utah Advisory Committee on Health Statistics.

The revised 1978 Utah birth certificate is divided into two sections, one being designated for health and medical use; one to be completed by the physician and the other by the parents (Mahoney et al., 1978). All five high risk criteria, as previously stated, are contained on the birth certificate. The portion to be answered by the parent responds to the high risk item dealing with hereditary childhood hearing loss. The physician's portion responds to the remaining four high risk criteria, those being: "rubella or other non-bacterial intrauterine fetal infections" in questions 25, 28, and 31-b; "defects of ear, nose, and throat, etc.; are reflected in question 33; "birthweight less than 1500 grams" is directly answered by question 32; and "bilirubin level greater than 20mg/100ml serum" is covered by question 25, 28, and 31-b (Mahoney et al., 1978). See page 23 for illustration.

A computer program for the extraction of high risk infants for hearing impairment was devised in cooperation with the Utah Bureau of Vital Statistics. The speech Pathology/Audiology Section of State Health receives a monthly readout of name and address for all infants with one or more high risk factors. A step-by-step follow-up program is initiated when the high risk infant is six to eight months old.
Certificate Items Representing Committee's Statement
Cited in Mahoney & Eichwald, 1978

The step-by-step procedure is:

1. A questionnaire is mailed to the parents. This questionnaire covers the following questions: (a) "When your child is in light sleep in a quiet room, does he move and begin to wake up when there is a sudden noise?" (b) "Does your child turn toward an interesting sound, or when his name is called?" (c) A question allowing the parents to express their own concerns about their child's hearing.

2. If questionnaires are not returned, no further action is taken. Returned questionnaires are evaluated on the basis of auditory behavior or parental concern.

3. Parents of infants remaining at risk are mailed a card requesting the parent to have their child evaluated audiologically by either a private audiologist or at one of the Utah State Health Service offices. The pre-paid postcard portion of the notice card requests the parent to check one of the above mentioned alternatives and return the card.

4. Parents requesting the assistance of the State Health Service are scheduled for an audiological assessment. Infants found to be
hearing impaired are contacted in regards to hearing aid evaluation and medical consultation.

5. Habilitation referrals are then made to the Utah School for the Deaf Parent Infant Program.

Since the first conference on identification of hearing impairment, many reasons have been given for its continuation as a screening devise. Factors cited in support of high risk screening are:

1. Downs & Stewart (1977) reported that 70-90% of all children who eventually are determined to be hearing impaired would show up on a high risk register.

2. The population accessible in Utah alone would be 98.9% of the total infants born (Utah Vital Statistics, 1977).

3. The cost of a high risk program is minimal for the initial screening (Mahoney et al., 1978).

4. Identification of children with progressive losses due to rubella, hyperbilirubinia, etc., which may not show their effects until later (Gerber, 1977).

5. It generates among professionals an interest regarding the significance and etiology of hearing loss (Meyer & Wolfe, 1975).

6. There are no problems in regards to those experienced by comprehensive behavioral screening programs; such as, habituation, optimal states, or observation errors (Mahoney et al., 1978).

While many are in favor of using a high risk register for screening purposes others have genuine reservations, such as:

1. The high risk method identifies only 70% of the hearing impaired infants. The remaining 30% are missed due to unknown etiologies (Northern & Downs, 1977).
2. Response to follow-up procedures are low. In spite of letters and phone calls, only 57% of those not cleared returned for retests (Meyer & Wolfe, 1975; and Shapiro, 1974).

3. Another problem cited was a high false positive rate in identifying children at risk (Mahoney et al., 1978).

Summary

Neonatal screening for hearing impairments is very important in working towards amelioration of the child's language handicap. With an incidence of two to three thousand hearing impaired births every year, a program of early detection is essential. With early identification, effective habilitation of language and hearing deficiencies can be incorporated early. Early identification is a primary step in alleviation of later difficulties experienced by the hearing impaired child.

As an early means to identify neonates with hearing impairments, behavioral audiometric techniques were employed. Difficulties with observable behaviors, observation reliability, habituation, and failure to identify certain types of children were experienced. "Baby beeping" under the recommendations of the Joint Committees was deemed to be profitable only in the realm of further research. Automated behavioral techniques hoped to eliminate the problems of the "baby beeping" approach but have yet to be proven as effective mass screening devices.

The brainstem evoked response of the electrophysiological measurements appears to be the most promising in regards to identification of hearing impairments in the neonate. Variance in the seven peaks, whether it be latency or morphological oriented, reveal different types
of hearing defects. Although it is effective in identifying hearing impairments, factors relating to cost, length of time in administration, and specialized training have hindered its use as a mass screening device.

Through interest generated by the neonatal screening conferences of 1969 through 1975, the high risk registers were identified as an effective way to screen for hearing impairment in infants. Utah, under the direction of the Utah State Health, initiated its first high risk register in 1969. This first register proved to be too lengthy and cumbersome. With guidelines set forth by the Joint Committee in 1973, a maternal questionnaire in the form of a seven-item high risk register, was designed to follow-up children at risk. Problems relating to high false positives and poor return rate led to the investigation of the use of the Utah birth certificate as a means of abstracting the high risk items. This program was introduced in 1978 and is currently under use.
CHAPTER III
METHODS AND PROCEDURES

Introduction

This research was a post-hoc, comparative study. The objective of the study was to compare two neonatal screening methods for hearing impairment. Data was abstracted from the Utah State Department of Health records regarding: (a) rate of return, (b) number of children identified as "high risk", "at risk", and "hearing impaired", (c) items responsible for risk classification, and (d) false positive rates. The data was abstracted, recorded, and analyzed as described in this chapter.

The methods and procedures utilized in obtaining the desired information are explained under the following headings: (a) population--description, (b) instrumentation, (c) research procedures, data collection and tabulation.

Population--Description

The population of neonates studied were all infants born in the State of Utah during the period of January 1, 1978 to July 1, 1978.

Instrumentation

During the period of January 1, 1978, to July 1, 1978, the Utah State Department of Health utilized two types of screening instruments in a state wide screening program. They were the maternal questionnaire and the birth certificate.

Maternal questionnaire. The maternal questionnaire consists of seven questions associated with the etiology of hearing impairment. They are: question one--hereditary hearing loss, question two--rubella, question three--birthweight, question four--Rh incompatibility, question
five--ear, nose, or throat defects, question six--neonatal illness, and question seven--parental concern. The questionnaire requires parents to mark a yes or no response for each of the seven questions. A yes response indicates a neonatal problem or an infant classified as "high risk", while a no response is classified as "not high risk". The Utah High Risk Maternal Questionnaire is displayed in figure 1.

The maternal questionnaires are distributed to all hospitals in Utah. Dissemination of the questionnaires is handled by the nurses at the same time the mandatory birth certificate is completed. Questionnaires are periodically accumulated and mailed to the Division of Speech and Audiology, Utah State Department of Health. A questionnaire is classified as "high risk" if one or more items is answered yes, or if a question is left unanswered. Questionnaires are sorted and filed as "high risk" or "not high risk". Following a six to eight month waiting period, a list of infant deaths by month is obtained through the Department of Vital Statistics. The deaths are purged from the questionnaires filed under "high risk". A follow-up questionnaire packet is mailed to the parents of those children who remain high risk for hearing impairment (see Appendix A).

The follow-up packet consists of a letter of explanation, a hearing check list, a follow-up questionnaire, and a pre-paid return envelope. The follow-up questionnaire is identical to the maternal questionnaire with the addition of two questions. The two questions relate to the parents' observations of the child's auditory response to sound. Responses to the follow-up questionnaire are matched with the original maternal questionnaire and filed according to the responses indicated.
**NEWBORN HEARING SCREENING QUESTIONNAIRE**

Please PRINT

<table>
<thead>
<tr>
<th>Baby's Name</th>
<th>Birthdate</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent's Name</th>
<th>Home Phone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Address</th>
<th>City</th>
<th>Zip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Baby’s Doctor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dear Parent:** Please fill out this information by circling YES or NO. ANSWER ALL QUESTIONS. If you need assistance, please contact the hospital nurse.

1. Has a close relative of the baby had a hearing loss SINCE CHILDHOOD? YES NO

2. During the pregnancy, was the mother exposed to RUBELLA (3 day, German, or “soft” measles)? YES NO

3. At birth, did the baby weigh LESS THAN 3½ pounds (1500 grams)? YES NO

4. Was there an RH (blood incompatibility) problem that required blood transfusion? YES NO

5. At birth, were there any defects involving the baby’s head, ears, nose, or throat? YES NO

6. Has the baby been SERIOUSLY ill since birth? YES NO

7. Do you have reason to be concerned about this child’s hearing? YES NO

**IF additional information is required, you may expect to receive a telephone call from a professional staff member within approximately six months. Should you have any questions, call 533-6175, Salt Lake City, Utah.**

**HOSPITAL STAFF:** Please mail the original to this address and place the carbon in the baby’s file, if desired.

Speech Pathology/Audiology Section  
Utah State Division of Health  
44 Medical Drive  
Salt Lake City, Utah 84113

Figure 1. The maternal questionnaire.
The criteria for risk on the follow-up questionnaire is a yes response to one or more of the questions. If the child remains at risk the maternal questionnaire and the follow-up are filed together under "at risk". If the follow-up is returned with the question regarding parental concern marked no, regardless of any positive responses on any of the other items, it is filed with the matching maternal questionnaire under "false positive". The children are no longer considered at risk. The "not at risk" file is composed of the follow-up questionnaires that are answered no for all nine questions. If the follow-up questionnaire is not returned the maternal questionnaire is filed under "no response". Postal problems or those returned unopened are filed under "unable to contact".

When a child is determined to be at risk by the follow-up questionnaire, a letter requesting information relating to the child's further assessment is mailed to parents. The assessment letter consists of a letter requesting an indication of what services the child is receiving related to the possible handicap, plus a pre-paid return envelope. See Appendix B for a copy of this letter. A check in the box indicating no concern is recorded as "no concern--normal" on an attached summary sheet. The summary sheet is attached to the combined maternal questionnaire and follow-up questionnaire. The file is then re-filed under "at risk". A check in the box indicating services acquired already are marked "other" with specific notations and re-filed under "at risk". Any forms not returned or returned due to postal problems are marked as "unresolved" and re-filed under "at risk". A check requesting assessment or continued concern are marked "hearing risk". The children
in this category are evaluated and recorded on the summary sheet as sensorineural, conductive, normal, or other. Follow-up service is initiated if needed.

**Birth certificate.** The birth certificate consists of six specific questions relating to hearing impairment which are similar to those posed by the maternal questionnaire. They are: number 23--hereditary related loss, number 25--complications during pregnancy, number 28--concurrent illnesses, number 31b--Apgar score, number 32--birthweight, and number 33--congenital malformations. Question 23 is answered by the parents marking yes if hereditary loss exists and a no if it does not. The other five questions are completed by the attending physician. Questions 25, 28, and 33 are fill-in the space type questions. Question 31b requires a numerical response of 1 to 10. A low Apgar score would be below five. Question 32 requires a numerical value in grams for birthweight. The Utah Birth Certificate as used for high risk hearing screening is shown as Figure 2.

The birth certificate program is different in the initial procedures from that of the maternal questionnaire program. The birth certificate is completed mandatorily after the infant's birth and returned to the Department of Vital Statistics. Certificates are processed by a computer and separated as "high risk" or "not high risk". A source document is a computer printout that lists the child's vital statistics and response to the high risk items. A source document is displayed in Appendix C. It is sent to the Speech Pathology and Audiology Division of Utah State Health on any birth certificate that is below normal limits. Normal limits are: a no response for question 23 relating to
Figure 2. The birth certificate.
hereditary hearing loss, 'absent' responses for questions 25, 28, and 33; a response of 1500 grams or lower for question 32; and an Apgar score poorer than five for question 31b. The source document is filed under "high risk" if it falls below normal limits. The follow-up procedures are identical to those used with the maternal questionnaire program.

Research Procedures--Data Collection, and Tabulation

Permission to use state records for this study was obtained from Dr. Peter C. van Dyck, Deputy Director of Health. Clearance was also obtained from the Committee of Human Subjects at Utah State University. These documents are displayed in appendix D and E.

The file system used by the Speech Pathology and Audiology Section of the Department of State Health consisted of three parts: (a) maternal questionnaires alone, (b) birth certificate (source documents) alone, and (c) matched birth certificates and maternal questionnaires.

The maternal questionnaire alone files consisted of high risk maternal questionnaires whose corresponding birth certificates were not high risk. Source documents were only forwarded on high risk infants. The birth certificate alone files consisted of high risk birth certificates source documents. Corresponding maternal questionnaires were never returned by the hospitals. The matched files consisted of maternal questionnaires and high risk birth certificates that were returned from both programs for the same infants.

A hand tabulation of the number of maternal questionnaires was completed and recorded categorically. The categories under the file system were: "not high risk", "not at risk", "false positive", "no
response", "unable to contact", and "at risk". The tabulation was accomplished by tallying all the questionnaires filed under maternal questionnaire alone and those filed under maternal questionnaire and birth certificate combined. The combined number classified as at risk and no response were filed differently and necessitated the abstraction of maternal questionnaires matched with birth certificates from the birth certificate file. Totals were recorded and summed for the total return rate for maternal questionnaires.

Tabulation of the birth certificates consisted of the same process, except for the category of not high risk. The numerical value for those not high risk on the birth certificates was obtained by subtracting those found to be high risk from the total live births. The total live births were established through the Department of Vital Statistics.

The number of infants found to be "hearing risk" by both screening methods were tabulated by examining the "at risk" files. The first divisions, recorded on the summary sheet for the maternal questionnaires and on the source document for the birth certificates, were hearing risk, normal, unresolved, or other. Hearing risk was then classified according to subsequent audiological evaluations as sensorineural, conductive, normal, or other.

Assessment of the items responsible for the placement of questionnaires and birth certificates into the different categories were recorded. A separate tally sheet of the items for maternal questionnaires alone, birth certificates alone, and combined maternal questionnaires and birth certificates were employed. Each category was examined and the findings recorded. The recording sheets consisted of numbers one through seven for the maternal questionnaires and one
through six for the birth certificates. See Appendix E for an example of raw data. The information was abstracted from the maternal questionnaire directly. A yes response was recorded with the corresponding number on the risk item tally sheet. The risk items on the birth certificate were abstracted from the source document. Items one, two, three, and six were classified as risk if a one was recorded on the source document. Item four was classified as risk for any number below five and item five was classified as risk if the numerical value was below 1500. Items found to be at risk were recorded on a tally sheet. A one-to-one risk item tally sheet was used in assessing the combined maternal questionnaire and birth certificate files. Totals were taken from the combined maternal questionnaire and birth certificate files and added to the totals of the tally sheets obtained from the maternal questionnaire and birth certificate alone files. All data collected by the above procedures is reported in table form in the Results and Discussion section. The data was treated mathematically for comparison purposes.

The data derived from this collection procedure was taken to a team of statisticians for analysis. The statisticians determined that the data did not lend itself to statistical analysis.
CHAPTER IV
RESULTS AND DISCUSSION

Introduction

The goal of the Utah state wide infant hearing screening program was to identify the highest yield of existing hearing impairments while maintaining a low false positive rate. The data derived from this study provides a comparison of the maternal questionnaire program and the birth certificate program. The data accumulated from Utah State Health records are displayed in table form and the salient information highlighted in this chapter.

Rate of Return

A comparison was made between the maternal questionnaire and the birth certificate to determine if there was any significant difference in return rates between the two methods of neonatal hearing screening. The numerical values tabulated for the forms returned were 43% for the maternal questionnaire and 100% for the birth certificate, as shown in Table 1.

Table 1

A Comparison of the Rate of Return of the Maternal Questionnaire and the Birth Certificate

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Number</td>
<td>%</td>
</tr>
<tr>
<td>Total Live Births</td>
<td>19,018</td>
<td>N.A.</td>
</tr>
<tr>
<td>Total Returned</td>
<td>8,038</td>
<td>43</td>
</tr>
<tr>
<td>High Risk</td>
<td>1,064</td>
<td>13.2</td>
</tr>
<tr>
<td>Deaths Purged</td>
<td>11</td>
<td>N.A.</td>
</tr>
</tbody>
</table>
The findings, as reported in Table 1, concerning the return rate for the maternal questionnaire support the findings by Mahoney, et al. (1978), indicating difficulties associated with low return rates. The birth certificate had a 100% return rate which was more than double the return rate for the maternal questionnaire.

Infants Identified as "High Risk" and "At Risk"

The second objective was to compare the number of infants identified as "high risk" and later as "at risk" by the two screening methods. The goal of both screening methods was to obtain the highest yield of hearing impaired infants while limiting the false positive population to as few as possible. Limiting the population reduces expense and time used in diagnosing normal infants. The tabulation of records, as shown in Table 1, yielded a 13.2% high risk rate for the maternal questionnaire and 6.8% high risk rate for the birth certificate. As a screening device the maternal questionnaire identified nearly twice as many infants as "high risk" as did the birth certificate. The goal as stated, of the screening program was to limit the population as much as possible in order to eliminate the false positive population. The birth certificate program limited the "high risk" population to half of those determined as "high risk" by the maternal questionnaire.

After administration of the follow-up questionnaire, six point three percent of the infants identified as high risk by the maternal questionnaire remained "at risk" as displayed in Table 2. Of the high risk infants identified by the birth certificate, eight point two percent remained "at risk". The birth certificate follow-up yielded a slightly higher percent of at risk infants, but in comparison to the percent
Table 2
A Comparison of High Risk Infants as Determined by the Follow-up to the Maternal Questionnaire and Birth Certificate Hearing Screening

<table>
<thead>
<tr>
<th>Classification</th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Number</td>
<td>% of High Risk</td>
</tr>
<tr>
<td>At Risk</td>
<td>67</td>
<td>6.3</td>
</tr>
<tr>
<td>Not At Risk</td>
<td>367</td>
<td>34.8</td>
</tr>
<tr>
<td>No Response</td>
<td>407</td>
<td>38.6</td>
</tr>
<tr>
<td>False Positive</td>
<td>151</td>
<td>14.3</td>
</tr>
<tr>
<td>Unable to Contact</td>
<td>61</td>
<td>5.8</td>
</tr>
</tbody>
</table>

N = 1053
N = 1190

of high risk identified by the maternal questionnaire it still maintained a lower false positive population. The remaining populations of both programs were categorized into different responses of false positives. The categories were tabulated in order to compare further differences if they existed. The salient factor abstracted from Table 2 was that 34/8% of the high risk infants identified by the maternal questionnaire were found to be "not at risk" as compared to 25.7% of those identified by the birth certificate. The other categories were approximately the same in percent of high risk. The ten percent difference between the two programs for "not at risk" was indicative of the too large of population initially screened as high risk by the maternal questionnaire.

Items of Risk Responsible for Classification as High Risk and At Risk

An item analysis was conducted to determine the numbers of children classified at risk by each of the screening items on both the maternal questions and the birth certificate.
The objective of the item analysis was to aid in the elimination of false positives by identifying the items common to those infants at risk and comparing them to the items in common with the false positive population.

The item analysis compared corresponding items found on each instrument and are displayed in table form. Each item is compared for high risk and at risk populations. The infants initially identified as "high risk" are separated into "at risk" and "total false positives". The infants remaining "at risk" following the follow-up are separated as "hearing risk" and "false positives". Numerical values are tabulated by item for: (a) total infants for each of the categories, (b) relative ratios on how the item relates a predictor, and (c) the percentages of the population. The number of cases represent the actual number of infants that were identified by the item. A point to recall from the section dealing with return rate is that the maternal questionnaire had only a 43% return rate of the birth certificate. In examining the number of cases, the two methods appear to be approximately the same, but in reality the maternal questionnaire is only representative of 43% of the total population. The total number of cases is representative of all of the infants for each of the separate divisions.

The relative ratio predicts how the item appears as a predictor of risk in relation to the total population. A value of one would be the expected value for every item on the maternal questionnaire and the birth certificate.

The above procedures were followed on all of the following: heredity, birthweight, illness, ENT abnormalities/congenital malformations,
rubella, Rh incompatibility, parental concern, Apgar score, and complications of pregnancy. It should be noted that heredity, birthweight, illness, and ENT abnormalities/congenital malformations are present on both screening devices and are compared in the next section. Rubella, Rh incompatibility, and parental concern are only present on the maternal questionnaire and therefore cannot be compared to the birth certificate. Apgar score and complications of pregnancy are present only on the birth certificate and therefore no comparison is made with the maternal questionnaire.

**Heredity.** An analysis of heredity as a predictor of "high risk" and "at risk" is shown in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk</td>
<td>Total</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>48</td>
<td>665</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
<td>986</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>1.07</td>
<td>1.0</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>70</td>
<td>66</td>
</tr>
</tbody>
</table>

* F+ = False Positive

The number of cases for both methods are comparative for the populations screened. The birth certificate method screened twice as many infants as did the maternal questionnaire. The heredity item identified approximately 65% of all the children found to be at risk on both methods. The
maternal questionnaire showed 93% of the hearing risk population as risk because of the heredity item. There was no apparent reason to determine why the maternal questionnaire had a higher percent of hearing risk for this item. The relative ratio depicted heredity to be a slightly better predictor of risk for the maternal questionnaire than would be expected and a slightly poorer predictor of risk for the birth certificate. To further illustrate Table 3 see Figure 3.

![Figure 3. Population of profiles of heredity as a predictor of high risk and at risk.](image)

*MQ = Maternal Questionnaire  
*BC = Birth Certificate

The population profile shows the hereditary item to be more of an indicator of risk than would be predicted for the maternal questionnaire. False positives were as expected for both methods. Both screening devices demonstrated a better than expected return on hearing risk.

**Birthweight.** The analysis for birthweight is shown in Table 4. The results demonstrate the identification rate for the birth certificate method to be three times greater than for the maternal questionnaire. The percentage of the total at risk population was 13% for the birth certificate and only five percent for the maternal questionnaire. This indicates that birthweight was responsible for twice as many at risk
infants for the birth certificate than it was for the maternal question-
naire. The hearing risk population depicted the same ratio. The
relative ratios for both methods showed a better than expected identifi-
cation attributed to the birthweight item for the at risk population.
See Figure 4 for a further illustration of Table 4.

Table 4

<table>
<thead>
<tr>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Risk *F+ Total *F+</td>
<td>At Risk *F+ Total *F+</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>Number of Cases</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>14</td>
<td>66</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>.96</td>
</tr>
<tr>
<td>Percentage of Total #</td>
<td>.95</td>
</tr>
<tr>
<td>of Cases</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>13</td>
</tr>
<tr>
<td>*F+ = False Positive</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Population profile of birthweight as a predictor of high risk
and at risk.
The hearing risk population for the maternal questionnaire was approximately the same relative ratio as for the at risk population. The birth certificate showed a lower than expected profile for the hearing risk population. The results show birthweight to be a good predictor of risk for a small proportion of the total population.

**Illness.** An analysis of the illness item is shown in Table 5.

Table 5

<table>
<thead>
<tr>
<th>Item Analysis of Illness as a Predictor of High Risk and At Risk</th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk</td>
<td>Total</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>5</td>
<td>79</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
<td>986</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>.93</td>
<td>1.0</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>7.5</td>
<td>8</td>
</tr>
</tbody>
</table>

*F+ = False Positive*

The number of cases for both methods are relatively small. The percentages of the total population identified by illness were comparable for both at risk and hearing risk. Salient information is further displayed in Figure 5. The relative ratio for the maternal questionnaire was approximately as predicted. The birth certificate showed concurrent illness to be a much better predictor for at risk, but a much poorer indicator at the hearing risk level. The false positive profile shows a higher than predicted value. The illness item appeared to be a good
indicator of risk, but was shown to be laden with false positives at the hearing risk level.

*MQ = Maternal Questionnaire
*BC = Birth Certificate

Figure 5. Population profile of illness as a predictor of high risk and at risk.

ENT abnormalities/congenital malformations. This item was labeled ENT abnormalities on the maternal questionnaire and congenital malformations on the birth certificate. The analysis of ENT abnormalities/congenital malformations is shown in Table 6.

Table 6

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk</td>
<td>Total</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>3</td>
<td>62</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
<td>986</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>.72</td>
<td>1.0</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>4.5</td>
<td>6</td>
</tr>
</tbody>
</table>

*F+ = False Positive
The birth certificate shows three times as many actual cases for at risk as did the maternal questionnaire and fewer false positives. In examining the percentage of the total populations the birth certificate identified twice as many cases at risk for ENT abnormalities/congenital malformations as did the maternal questionnaire. The relative ratios depicted on the population profile on figure 6 show the maternal questionnaire to be below the expected profile for at risk, but a better than expected predictor for hearing risk.

![Population Profile Diagram](image)

*MQ = Maternal Questionnaire  
*BC = Birth Certificate

Figure 6. Population profiles of ENT abnormalities/congenital malformations as a predictor of high risk and at risk

The birth certificate in comparison showed congenital malformations to be double the predictor for at risk, but a very poor indicator of hearing risk. Congenital malformation proved to produce a higher incidence of false positive cases.

The next three items appeared on the maternal questionnaire only and therefore the results were not compared with the birth certificate.

Rubella. The analysis of the rubella item was made for the maternal questionnaire only and displayed in Table 7.
Table 7

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk</td>
<td>Total *F+</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>5</td>
<td>137</td>
</tr>
<tr>
<td>Total Number of</td>
<td>67</td>
<td>986</td>
</tr>
<tr>
<td>Cases</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>.55</td>
<td>1.0</td>
</tr>
<tr>
<td>Percentage of</td>
<td>7.14</td>
<td>14</td>
</tr>
<tr>
<td>Total # of Cases</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

*F+ = False Positive

The percentage for the false positives was twice that found for the at risk population. Hearing risk failed to identify any infants. Figure 7 further demonstrates the relative ratios for the rubella item. It appeared to be a poorer than expected predictor of risk as seen on the figure.

*MQ = Maternal Questionnaire
*BC = Birth Certificate

Figure 7. Population profiles of rubella as a predictor of high risk and at risk.
Rh incompatibility. The analysis of Rh incompatibility is shown on Table 8 and Figure 8.

Table 8
Item Analysis of Rh Incompatibility as a Predictor of High Risk and At risk for the Maternal Questionnaire

<table>
<thead>
<tr>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Risk</td>
<td>Total *F+</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>1</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>0.45</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>2</td>
</tr>
</tbody>
</table>

*F+ = False Positive

*MQ = Maternal Questionnaire
*BC = Birth Certificate

Figure 8. Population profiles of Rh incompatibility as a predictor of high risk and at risk

The population in concern was smaller than for rubella but all results were comparable to those found for it. The results indicate that Rh incompatibility is a poor indicator of risk.
Parental concern. The analysis of the item relating to parental concern is displayed in Table 9.

Table 9
Item Analysis of Parental Concern as a Predictor of High Risk and At Risk for the Maternal Questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk *F+</td>
<td>Total *F+</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>25</td>
<td>109</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>67</td>
<td>986</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>2.9</td>
<td>.87</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>37</td>
<td>1</td>
</tr>
</tbody>
</table>

*F+ = False Positive

The percentage of the high risk population for the at risk infants of 30% was three times that of the false positives. This indicates parental concern was a good indicator of risk and maintained a low degree of false positives. Figure 9 further illustrates the relative ratios.

Figure 9. Population profiles of parental concern as a predictor of high risk and at risk.
The at risk ratio was three times the expected value. In comparing the at risk ratio to the hearing ratio, it is apparent that the at risk ratio over predicted the risk population and is therefore a poor indicator of risk.

The next two items appeared on the birth certificate alone.

**Apgar score.** The analysis of Apgar scores is shown on Table 10.

### Table 10

| Item Analysis of Apgar Score as a predictor of High Risk and At Risk for the Birth Certificate |
|---|---|---|---|---|---|---|---|
| | Maternal Questionnaire | Birth Certificate | | | | | |
| | At Risk | Total *F+ | Hear Total | Total *F+ | At Risk | Total *F+ | Hear Total | Total *F+ |
| Number of Cases | - | - | - | - | 26 | 244 | 9 | 19 |
| Total Number of Cases | - | - | - | - | 98 | 1065 | 31 | 67 |
| Relative Ratio | - | - | - | - | 1.15 | .98 | 1.02 | 1.0 |
| Percentage of Total # of Cases | - | - | - | - | 27 | 23 | 29 | 30 |

*F+ = False Positive

The population identified by the Apgar item was 27% of those identified as at risk and 29% of those identified as hearing risk. Figure 10 further illustrates the relative ratios determined for the Apgar item. This item was a stable predictor of risk for both at risk and hearing risk. The false positive profiles were also as would be expected. The Apgar score can be considered a good screening item because of its constancy as a predictor of risk.

**Complications of pregnancy.** The analysis of this item is shown on Table 11.
*MQ = Maternal Questionnaire
*BC = Birth Certificate

Figure 10. Population profiles of Apgar score as a predictor of high risk and at risk

Table 11

Item Analysis of Complications of Pregnancy as a Predictor of High Risk and At Risk for the Birth Certificate

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Risk</td>
<td>Total *F+</td>
</tr>
<tr>
<td>Number of Cases</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Number of Cases</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Relative Ratio</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Percentage of Total # of Cases</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*F+ = False Positive

The percentage of the at risk population identified was 36% and 26% for the hearing risk. Figure 11 illustrates the relation of the relative ratios to the population of risk infants. The population of at risk was a higher predictor than expected but a poor indicator for hearing
Figure 11. Population profiles of complications of pregnancy as a predictor of high risk and at risk. Complications of pregnancy would be expected to produce more false positives than are desired in a screening item.

**Actual Yield of Infants With Hearing Loss**

The goal of both hearing screening programs was to identify those infants with hearing impairments. The maternal questionnaire had a yield of one sensorineural and four conductive hearing impairments. The birth certificate method yielded four sensorineural and twenty-one conductive hearing impairments. All five children identified by the maternal questionnaire were also identified by the birth certificate method. The maternal questionnaire failed to provide any different impaired infants than those identified by the birth certificate. The birth certificate method yielded a three to one identification rate as compared to the maternal questionnaire.

**Item Analysis of Infants Identified as Hearing Impaired**

One of the objectives of this study was to determine items of risk which were in common with those infants determined to be hearing impaired.
The results of an item analysis to determine which items on the screening devices yielded specific types of hearing loss are displayed on Table 12.

### Table 12
**Hearing Impaired Item Analysis**

<table>
<thead>
<tr>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensorineural</strong></td>
<td></td>
</tr>
<tr>
<td>Hereditary</td>
<td>Hereditary</td>
</tr>
<tr>
<td></td>
<td>Hereditary</td>
</tr>
<tr>
<td></td>
<td>Hereditary</td>
</tr>
<tr>
<td></td>
<td>Hereditary</td>
</tr>
<tr>
<td></td>
<td>Hereditary</td>
</tr>
<tr>
<td><strong>Conductive</strong></td>
<td></td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + Concern</td>
<td>Hereditary</td>
</tr>
<tr>
<td>Hereditary + ENT Defects + Concern</td>
<td>Hereditary + Congenital Defects</td>
</tr>
<tr>
<td></td>
<td>Hereditary + Concurrent Illness</td>
</tr>
<tr>
<td></td>
<td>Complications + Apgar</td>
</tr>
<tr>
<td></td>
<td>Complications + Apgar</td>
</tr>
<tr>
<td></td>
<td>Complications + Apgar</td>
</tr>
<tr>
<td></td>
<td>Complications + Birthweight</td>
</tr>
<tr>
<td></td>
<td>Complications + Apgar + Birthweight</td>
</tr>
<tr>
<td></td>
<td>Apgar</td>
</tr>
<tr>
<td></td>
<td>Apgar</td>
</tr>
</tbody>
</table>

N = 5  
N = 25

All of the infants identified with a sensorineural hearing loss were attributed to the item on hereditary related hearing loss on both screening methods. The hereditary item was responsible for 55% of infants listed under conductive hearing loss. Complications and Apgar were responsible for identifying 20%, Apgar alone for 10% and the remaining...
15% were a combination of two or more items. It was noted that of the 25 infants identified as hearing impaired, 17 were identified as risk by the hereditary item.

**False Positive Rates**

Screening for hearing impairment was employed to alleviate the unnecessary testing of normal hearing infants. An important part of this research was in examining the number of infants identified as risk for hearing impairment but actually had normal hearing. The rate of infants identified as risk that had normal hearing determined the false positive rate.

Table 13 displays the false positive rates for each step of the identification process.

<table>
<thead>
<tr>
<th></th>
<th>Maternal Questionnaire</th>
<th>Birth Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual False Positives</td>
<td>Projected False Positives</td>
</tr>
<tr>
<td>At Risk</td>
<td>968</td>
<td>2,349</td>
</tr>
<tr>
<td>Hearing Risk</td>
<td>52</td>
<td>123</td>
</tr>
<tr>
<td>Hearing Impaired</td>
<td>10</td>
<td>23</td>
</tr>
</tbody>
</table>

Actual N = 8,038

Projected N = 19,018

In comparing the false positive rate of the two methods, attention is called to the high risk percentage reported in Table 1 for each method. The high risk rate was found to be approximately two-to-one for the
maternal questionnaire as compared to the birth certificate. In place of the 43% return rate, a projected return rate of 100% was assumed for the maternal questionnaire in order to create a comparable population. Projected data was made using the high risk rate of 13.2% for the total population of 19,018 even though the maternal questionnaire had on 8,038 returned.

The percentage of false positives identified out of the original "high risk" population were similar for both methods. The actual number of projected false positive infants for the maternal questionnaire is double that of the birth certificate.

The majority of the false positives identified in the hospital screening were eliminated following the follow-up questionnaire. The projected false positive rate for the maternal questionnaire was again determined to be twice that of the birth certificate.

Following the final follow-up to determine those infants classified as hearing risk, .5% were found to be false positive for the birth certificate compared to the .9% also positive rate for the maternal questionnaire.

The false positive rate for the maternal questionnaire was double that of the birth certificate through the initial screening stages. Even with the projected figures the maternal questionnaire program would be predicted to yield only half as many hearing impaired infants and consequently twice as many false positives.
CHAPTER V
SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Introduction

This research was conducted to obtain comparative information concerning the Utah maternal questionnaire and the birth certificate as screening instruments for hearing impairment in infants. Gerber (1977) stated that deafness doesn't just happen, but is caused. He continued to say that the knowledge of the cause should enable one to anticipate severe hearing problems at birth and thereby facilitate the prevention or amelioration of the handicap.

The Nova Scotia Conference of 1972 recommended an emphasis be placed upon the identification of a high risk population. Items to be considered as risk indicators were: hereditary related hearing loss, rubella, defects of the ear, nose, and throat, low birthweight, and Rh incompatability or high bilirubin levels.

Acknowledging the concern of the Joint Committee, the Utah State Department of Health's Division of Speech Pathology and Audiology, developed the first state wide screening program using a maternal questionnaire. Problems relating to hospital participation, patient follow-up, low return rates and high false positive rates were encountered. In hope of alleviating the problems an alternative method, the birth certificate, was introduced.

The goal of a screening program is to obtain the greatest possible yield of infants with a hearing impairment, while maintaining the lowest possible false positive rate. The items responsible for such a yield are important to consider in developing a successful screening program.
The objective of this study was to compare the maternal questionnaire and the birth certificate screening programs in regards to the goals of a screening program.

**Literature Review**

Cole (1979) stated that one of the most prevalent chronic disabilities present in today's young children is hearing impairment. Early screening of infants for hearing impairment is important in providing a greater awareness of the problem and providing a catalyst for early effective habilitation. Menyuk (1977) stressed the importance of the term "early" in early detection. The development of a child's language and cognitive functions are begun early in life. The need for early detection is further exemplified by the incidence of two or three thousand hearing impaired births per year. Clark and Watkins (1978) stated that without early identification, the early intervention necessary to provide optimal opportunities for language development is not possible.

Early methods of identifying hearing impairment in infants relied on behavioral audiometric techniques. These early methods were laden with problems relating to: observable behaviors, observation reliability, habituation, and failure to identify certain types of progressive losses. Automated behavioral techniques offered some hope in the alleviation of the problems experienced by their forerunners, but have yet to be proven effective as mass screening devices.

The advent of the computer introduced the area of the electrophysiological measurements. Such measurements remain in the realm of research except for evoked brainstem audiometry. The potential for identifying
hearing impairments is great, but is limited by factors of cost, administration time, and the need for specialized supervision.

The need for a quicker, more cost efficient, mass screening device resulted in several neonatal conferences from 1969 to 1975. The recommendation of the various conferences was the need of a high risk register to use in screening infants for hearing impairment.

The Utah Department of Speech Pathology and Audiology initiated the first state wide screening program in 1969 using a high risk register. The first register proved to be too lengthy and cumbersome. Adopting the seven items recommended by the Joint Committee of 1973, a maternal questionnaire program was introduced. Difficulties with high false positive rates and poor return rates hindered its effectiveness. In hopes of alleviating the problems experienced by the maternal questionnaire a revised birth certificate was introduced in 1978. This study was conducted in order to compare the maternal questionnaire program and the birth certificate program for the same population during the period of January 1, 1978, to July 1, 1978.

Methods and Procedures

The following topics were discussed in order to describe both methods and procedures used in the study. They were: (a) population--description, (b) instrumentation, (c) procedures, and (d) data collection and tabulation.

Instrumentation. The maternal questionnaire consisted of seven questions indicative of etiological factors relating to hearing impairment. They were: (a) hereditary related hearing loss, (b) rubella, (c) birthweight, (d) Rh incompatibility, (e) ear, nose, and throat defects, (f) neonatal illness, and (g) parental concern. Classification as "high risk" was dependant on a yes response to any of the seven items.

The birth certificate consisted of six items associated with the etiology of hearing impairment. They were: (1) hereditary hearing loss - #23, (2) complications during pregnancy - #25, (3) concurrent illness - #28, (4) Apgar score - #31b, (5) birthweight - #32, and (6) congenital malformations - #33. Classification of "high risk" was dependant upon a response found to be below normal limits.

The follow-up portion of both programs consisted of a questionnaire. Parents were requested to respond to the nine questions. Seven of the nine questions were identical to the seven questions posed by the maternal questionnaire. The additional two questions related to observed auditory behaviors. Parents were requested to respond to the follow-up questionnaire with a yes or no response. Any yes responses were classified as "at risk".

The maternal questionnaire and birth certificate were distributed to all hospitals in Utah. The maternal questionnaire was completed by the parents alone. The birth certificate required the parents to respond to the hereditary related loss and the attending physician to complete the remaining five items. Maternal questionnaires were accumulated and returned to the Department of Speech Pathology and
Audiology. The birth certificate, a mandatory document, was completed and sent to the Department of Vital Statistics where a computer sorted out those infants that were "high risk". A source document was then sent to the Department of Speech Pathology and Audiology for all infants that were high risk.

Following the waiting period of six to eight months a questionnaire was sent to the parents of those infants classified as "high risk". The returned follow-up questionnaires were attached to either the source document or the original maternal questionnaire and filed according to the response of the follow-up questionnaire. The files consisted of "at risk", "not at risk", "no response", "F+" or false positive, and "unable to contact".

A letter requesting information, relative to the infant's current services for the possible handicap, was sent to those parents of infants who were classified as "at risk". The returned information was filed with the source document or with the original maternal questionnaire under "at risk" for "normal", "unresolved", and "other". Those requesting service or evaluation were evaluated. The results of the evaluation were recorded on the summary sheet for the maternal questionnaires and on the source document for the birth certificates. If they had a hearing loss the original maternal questionnaire or birth certificate source document they were filed under "at risk".

Research procedures—data collection and tabulation. The raw data for each program was compiled and recorded on tables for each separate classification. Tests of statistical significance were not used due to the size of the population in question and the lack of randomization.
Tables describing specific characteristics of the two screening methods study programs were compiled for the following areas: (a) rate of return, (b) infants identified as "high risk" and "at risk", (c) items of risk responsible for classification as "high risk" and "at risk", (d) actual yield of infants with hearing loss, (e) item analysis of infants identified as hearing impaired, and (f) false positive rates.

Results and Discussion

The data obtained through the examination of Utah State Health records was displayed in table form and then discussed. The results obtained from compiling the number of forms returned by the maternal questionnaire and the birth certificate indicated a more than double rate of return for the birth certificate compared to the maternal questionnaire.

Infants identified as "high risk" yielded a 13.2% high risk rate for the maternal questionnaire and only a 6.8% high risk rate for the birth certificate. The birth certificate method limited the high risk population to half that of the maternal questionnaire. The high risk infants later classified as "at risk" yielded a 6.3% rate for the maternal questionnaire and a 8.2% rate for the birth certificate. The birth certificate yield confirmed the finding of the high risk population that found a more limited screened population of fewer unwanted false positives.

The item analysis of high risk forms for both programs depicted good and poor indicators of risk for the population studied. The maternal questionnaire showed the items concerning birthweight and parental concern to have been better than expected predictors of risk.
The hereditary and illness items were as expected. Ear, nose, and throat abnormalities, Rh incompatibility, and rubella items proved to be poorer than expected predictors of risk. The birth certificate item analysis found birthweight, concurrent illness, and congenital malformations to be better than expected indicators of risk. Hereditary, Apgar, and complication items were as predicted for the population studied.

A further analysis of the "at risk" population found the hereditary item to be the most indicative of those infants found to be hearing impaired. Birthweight proved to be a good indicator of risk for the maternal questionnaire. Abnormalities of the ear, nose, and throat also yielded a greater incidence of infants at risk than was predicted. Consideration of the limited population actually identified by the maternal questionnaire must be taken into effect when examining the items from the questionnaire and relating them to a projected outcome for a similar program. The birth certificate yielded a higher incidence of false positives for birthweight, concurrent illness, and congenital malformations that were expected. All three items had been considered a better than expected predictor of "high risk", yet in the identification of hearing impairment were of little value for the population studied.

A summary of the actual yield of hearing impairment for each program is shown on Figure 12. The maternal questionnaire identified only five of the 25 infants found to be hearing impaired. In comparing the birth certificate method to the maternal questionnaire method a three to one identification rate ratio was noted. The maternal questionnaire produced only those infants identified by the birth certificate yielding no new information.
Figure 12. Populations identified as risk by the maternal questionnaire, the birth certificate, or both.

The item found to be in common with the majority of the infants identified as hearing impaired was hereditary hearing loss. All other items accounted for only 35% of the hearing impaired population.

The false positive rate for the maternal questionnaire was found to be twice that of the birth certificate. Even using projected data, maintaining actual percentage yields, the maternal questionnaire would only produce half as many actual hearing impaired infants as the birth certificate method. The birth certificate program produced a higher
yield of actual hearing impaired infants while maintaining a lower false positive rate than the maternal questionnaire.

**Conclusions**

The research problem was to compare the usefulness of the maternal questionnaire and birth certificate programs as neonatal hearing screening devices. The goal of a hearing screening program is to obtain the greatest yield of actual hearing impaired infants while maintaining the lowest possible false positive rate.

The objectives of the study were chosen in order to compare specific characteristics of both programs. Comparative information was obtained for: (a) rate of return, (b) number of infants identified as "high risk" and "at risk", (c) item analysis for "high risk" and "at risk" infants, (d) actual yield of infants with hearing impairments, (e) item analysis of infants identified as hearing impaired, and (f) false positive rates.

The birth certificate screening method was the better screening method of the two. It maintained a higher return rate, a lower false positive rate, and a much larger yield than was found for the maternal questionnaire.

In assessing the items responsible for the infants identified as hearing impaired, hereditary related hearing loss was the most prevalent. This item actually produced more high risk, at risk, and hearing risk than all other items combined. As shown in Table 3 the hereditary item was also a large factor in contributing to false positives. A more specific assessment of the relationship of the hereditary linking problem could prove to be more profitable.
Comparing the high risk yields of the two screening devices, the item concerning parental concern on the maternal questionnaire appeared too early to be of value in assessing the risk of an infant. It proved only to serve as a good predictor of false positives. In contrast, when presented on the follow-up questionnaire the parents responded more as would be predicted.

It is of interest to compare the two programs and see the difference between parents responses and those of the attending physicians. Parents appear to be less aware of the infant's condition at birth. This was apparent with the item on parental concern. A majority of those infants identified as "high risk" were alleviated after the waiting period had passed and the follow-up was sent. The question exists if the parent really has a basis to make sound judgments concerning their infant during the short hospital stay.

In examining the item analysis for both programs the maternal questionnaire was of little value except in comparing the two programs. Its value was limited because of the small population found to be hearing impaired. The maternal questionnaire proved to be a poor indicator of risk and inversely a good indicator of false positives.

The item analysis for the birth certificate program provided information concerning the population studied. For the study population, hereditary hearing loss was the most yielding item. Birthweight, concurrent illness, and congenital malformations, although initially better than expected predictors of risk, were actually poor indicators of actual hearing impairment. The use of a more limited and specific classification of hereditary hearing loss, concurrent illness, and congenital
malformations would hopefully eliminate more of the false positives and continue to maintain a high rate of identification.

The results of this study provided relevant information concerning Utah's state wide neonatal hearing screening programs. The study can serve to give a better insight into a possible means of effectively identifying hearing impairment in infants. The birth certificate method provides a promising means of a low cost, efficient method of identifying hearing impairment in infants.

Suggestions for Further Research

A study of the hearing impaired children in the Parent-Infant Program from ages two to five would be helpful in further assessing the usefulness of the birth certificate screening program. Through special case studies of the Parent-Infant children and examination of their birth certificate records, much information could be obtained. A comparison of the items found to be responsible for their classifications could be beneficial.

Hereditary related hearing loss was found to be the best indicator of actual hearing loss for the birth certificate program. It was also noted that it proved to be an equal indicator of false positives. A more indepth study of the item dealing with hereditary related hearing loss should be conducted in order to aid in the elimination of false positives. A more specific follow-up questionnaire could assist in the classification of infants at risk according to the relationship of the person reported to have been hearing impaired. This analysis could assist in further limiting the population to only those infants actually impaired.
A final topic of research would be an examination of the items relating to concurrent illness, birthweight, and congenital malformations. These items showed a high degree of false positive identification, but were also present in those infants identified as hearing impaired. An in-depth study of these items could assist in creating a better screening device.
REFERENCES


Appendix A
Newborn Screening Follow-up Questionnaire

NEWBORN HEARING SCREENING QUESTIONNAIRE

Please PRINT

FOLLOW-UP

Baby’s Name ___________________ Birthdate _______________ Sex _______________
Parent’s Name ___________________ Home Phone _______________ Date _______________
Address ___________________ City _______________ Zip _______________
Hospital ___________________ Baby’s Doctor ___________________

Dear Parent: Please fill out this information by circling YES or NO. ANSWER ALL QUESTIONS.

1. Has a close relative of the baby had a hearing loss SINCE CHILDHOOD? YES NO
   IF YES, DESCRIBE

2. During the pregnancy, was the mother exposed to RUBELLA (3 day, German, or “soft” measles)? YES NO
   IF YES, DESCRIBE

3. At birth, did the baby weigh LESS THAN 3½ pounds (1500 grams)? YES NO

4. Was there an RH (blood incompatibility) problem that required blood transfusion? YES NO

5. At birth, were there any defects involving the baby’s head, ears, nose, or throat? YES NO
   IF YES, DESCRIBE

6. Has the baby been SERIOUSLY ill since birth? YES NO
   IF YES, DESCRIBE

7. Do you have reason to be concerned about this child’s hearing? YES NO
   IF YES, DESCRIBE

8. When your child is in a light sleep in a quiet room, does he move and begin to wake up when there is a sudden noise? YES NO
   IF NO, DESCRIBE

9. Does your child turn toward an interesting sound or when his name is called? YES NO
   IF NO, DESCRIBE

Speech Pathology / Audiology Section
Utah State Division of Health
44 Medical Drive
Salt Lake City, Utah 84113

SDH-BSHS-16-3/77
Appendix B
Letter of Services Follow-up

Dear

You recently returned our follow-up questionnaire on newborn hearing screening. Because you expressed concern about your child's hearing and we have been unable to contact you by telephone, we would appreciate more information. Please mark the appropriate box below and return this letter in our self addressed stamped envelope or contact us at 533-6175. We appreciate your cooperation.

☐ I am not presently concerned about my child's hearing.

☐ I am concerned about my child's hearing, but he/she is presently receiving services. ☐ private physician ☐ state services ☐ other (specify) __________

☐ I am concerned about my child's hearing and I would like to have his/her hearing evaluated. Please send me an appointment date at ☐ Salt Lake ☐ Ogden ☐ Vernal ☐ other ________

The Speech Pathology/Audiology Section of the Utah State Division of Health does offer diagnostic hearing, speech, and language evaluations. These services are provided without charge at our permanent clinics in Salt Lake, Ogden, and Vernal and at our traveling clinics throughout the State. YOUR BABY'S HEARING CAN BE TESTED AT ANY AGE.

Sincerely,

Tom Mahoney, Ph.D., Director
Speech Pathology/Audiology

Enclosures: 1

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Division of Health
Family Health Services Branch
Peter C. van Dyck, M.D., M.P.H.
Deputy Director of Health

Speech Pathology & Audiology Section
44 Medical Drive
Salt Lake City, Utah 84113
801-533-6175

An Equal Opportunity Employer
Appendix C

Source Document

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** TOTAL RECORDS IN THE CATEGORY (01-ST-FILE-NO = 7902111) **
Appendix D

Letter of Permission from Department of State Health

December 17, 1979

Pater C. Van Dyck, M.D. MPH
Director of Family Health Services
Utah State Division of Health
44 Medical Drive
Salt Lake City, UT 84113

Dear Dr. Van Dyck:

Carl H. Clark is a master degree student in Audiology at Utah State University. He has completed several audiology courses which deal with early identification and intervention of auditory problems which have provided him with an excellent background on which to pursue his proposed thesis. He has expressed his interest in comparing such data as yield, identification factors of the High Risk Registar, and other differences between use of the maternal questionnaire and use of the birth certificate for the first six months of 1978.

Would you please respond concerning the possibility of Carl using State Health data for thesis purposes.

Sincerely,

Dr. Thomas C. Clark, Assoc. Professor

Sue Watkins, Instructor

Dr. Steven H. Viehweg, Assoc. Professor
Department of Communicative Disorders
Utah State University
Logan, UT 84322

cc: Dr. Thomas Mahoney

Ronda Condie
MEMORANDUM

TO: Thomas C. Clark and Carl H. Clark

FROM: Joseph Gappa


The above referenced proposal has been reviewed and approved by the institutional Review Board.
# Appendix F

## Raw Data Collection for the Maternal Questionnaire

<table>
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### 1. Hereditary

| Jan | 26 | 31+ | 5  | 9+ | 33-9x | 6x | 1+ | 3+ | 1-2 |
| Feb | 13 | 13+ | 4  | 6  | 16+18 | 16+ | 1+ | 3+ | 1-3+ |
| Mar | 14 | 17+ | 8  | 9  | 12+16x | 6+ 1x | 5+ | 1-7+ |
| Apr | 6  | 6x  | 2  | 8+ | 15+28x | 3+ 3o | 5+ | 1-2+ |
| May | 17+ | 19+ | 6  | 10+ | 14+26x | 2+ 2 | 9+ | 3+ 35+ |
| June | 12+ | 19+ | 7  | 12+ | 14+23x | 2+ 3+ | 1  |

### 2. Rubella

| Jan | 1  | 17+ | 0  | 2  | 0+10x | 0  | 1  | 1+ | 1+1+ |
| Feb | 0  | 3  | 0  | 1  | 0+7  | 0  | 0  | 2x | 2x |
| Mar | 6  | 10+ | 0  | 3  | 0+6x  | 0  | 0  | 3 | 3+ |
| Apr | 0  | 3  | 0  | 1  | 0+5x | 0  | 0  | 1  | 1+ |
| May | 0  | 3  | 0  | 5  | 0+11 | 0  | 0  | 1  | 1+ |
| June | 0  | 3  | 0  | 2+ | 0+8x | 0  | 0  | 1  | 1+ |

### 3. Birthweight

| Jan | 0  | 1  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| Feb | 0  | 1  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| Mar | 0  | 1  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| Apr | 2  | 0  | 0  | 2  | 0+10 | 0  | 0  | 0  | 0  |
| May | 0  | 1  | 0  | 2  | 0  | 0  | 6  | 0  | 0  |

### 4. Rh Factor

| Jan | 0  | 1  | 0  | 1  | 0+3x | 0  | 0  | 0  | 0  |
| Feb | 0  | 3  | 0  | 1  | 0+3  | 0  | 0  | 0  | 0  |
| Mar | 0  | 2  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| Apr | 0  | 3  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| May | 0  | 3  | 0  | 1  | 0+2x | 0  | 0  | 0  | 0  |
| June | 0  | 3  | 0  | 1  | 0  | 0  | 0  | 0  | 0  |

### 5. EMT Defects

| Jan | 1x  | 3  | 0  | 1  | 0  | 3  | 0  | 0  | 0  |
| Feb | 0  | 5  | 0  | 1  | 0  | 1+ | 0  | 0  | 0  |
| Mar | x  | 1x  | 0  | 1  | 0  | 2  | 0  | 0  | 0  |